



**Preliminary Foundation Investigation
Report
Stewart Boulevard Underpass
Replacement - Site No. 16X-0121/B0**

Highway 401 Rehabilitation
Brockville, ON

G.W.P. 4003-19-00

Latitude 44.599462
Longitude -75.701292

Geocres No. 31B-107

Prepared for:
Ministry of Transportation Ontario

Prepared by:
Stantec Consulting Ltd.
400 – 1331 Clyde Avenue
Ottawa, ON K2C 3G4

Project No. 165001160 (309)

February 2023

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PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS REPLACEMENT - SITE NO. 16X-0121/B0

Introduction
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PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT

For
G.W.P 4003-19-00

Highway 401 Rehabilitation, Brockville, Ontario
Highway 401 Stewart Boulevard Underpass (Site No. 16X-0121/B0)

Brockville, Ontario

1.0 INTRODUCTION

The Ministry of Transportation Ontario (MTO) has retained Stantec Consulting Ltd. (Stantec) to undertake an Environmental Assessment and complete the Preliminary Design for the replacement or rehabilitation of various structures along Highway 401 in the City of Brockville. The project limits extend from about 2 km west of the Highway 401 and Stewart Boulevard Interchange to 750 m east of the Highway 401 and North Augusta Road Interchange for a total length of approximately 4.5 km (G.W.P. 4003-19-00).

The foundation engineering services for the project includes the preparation of preliminary foundation investigation and design reports at 4 bridge (overpass or underpass) sites and one culvert site where replacement of the existing structures is planned. This report presents the results of a preliminary foundation investigation related to the replacement of the Stewart Boulevard (Highway 29) underpass structure at Site No. 16X-0121/B0. Separate Preliminary Foundation Investigation and Design Reports will be prepared for the other structure sites included in this assignment.

The purpose of the preliminary foundation investigation was to provide information on the subsurface conditions at the location of the proposed bridge reconstruction by drilling two boreholes, carrying out in-situ testing and completing a laboratory testing program on selected soil and bedrock samples obtained from the boreholes.

This Preliminary Foundation Investigation and Design Report (FIDR) has been prepared specifically and solely for the proposed replacement of the Stewart Boulevard underpass at Highway 401 (Site No. 16X-0121/B0). This preliminary report is not to be used for the detail design of this project; a Final Foundation Investigation and Design Report will need to be completed in the future after additional site investigation has been carried out.



PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS REPLACEMENT - SITE NO. 16X-0121/B0

Site Description
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2.0 SITE DESCRIPTION

2.1 SITE LOCATION

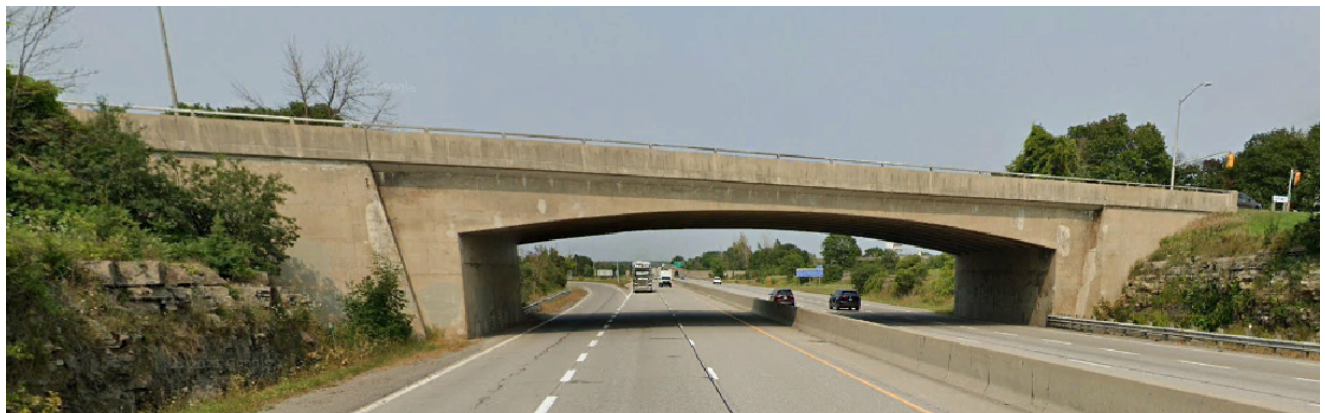
Stewart Boulevard crosses over Highway 401 near Station 21+374, in the City of Brockville, Ontario. The site location is shown on the Key Plan inset on the Borehole Locations and Soil Strata Plan, Drawing No. 1 in Appendix A.

2.2 SITE DESCRIPTION

At the Stewart Boulevard interchange, Highway 401 is a four-lane divided freeway with two lanes in each direction that is aligned in an approximate southwest-northeast orientation. There are also two on-ramp/entrance speed change lanes (one in each direction) present beneath the bridge structure. Stewart Boulevard is a four-lane undivided roadway that crosses over Highway 401 on a single-span bridge structure. For the purposes of this report the underpass structure will be referenced as being orientated south to north.

The ground surface surrounding the underpass site consists of relatively flat terrain within an overall slope towards the St. Lawrence River to the south. At the bridge site, the highway has been developed within a cut with bedrock exposed in the cut faces adjacent to all four quadrants of the bridge.

The existing bridge is a single-span, T-beam rigid frame structure constructed in 1958 (Contract 57-53) with a span length of 38.4 m and a width of approximately 18.3 m. The centerline of the structure is on an 18°49' skew to Highway 401 and traverses over six lanes of traffic (4 through-lanes and 2 on-ramp/entrance speed change lanes). There are concrete barrier walls with railings and sidewalks on both the west and east side of the structure. A photo of the bridge looking towards the west is provided below.



The bridge abutments are supported on shallow footings on bedrock. Wing walls, also supported on shallow footings, are present adjacent to the abutments at all four corners of the bridge.

The land within the interchange is undeveloped and contains vegetative cover consisting of grass, brush, and/or trees. The lands to the north and south of the highway and interchange contain commercial developments.



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2.3 SITE RECONNAISSANCE

The following items were noted during a site visit completed by Stantec personnel.

- No visible signs of settlement or deformation of the existing structure was noted. Areas of delamination and spalling with exposed rebar were visible at numerous locations.
- The asphalt wearing surface on the bridge exhibits longitudinal and transverse cracks and patched potholes.
- No signs of embankment settlement or instability were observed.
- The bedrock in the cut faces to the east and west of the bridge is typically thinly bedded and heavily fractured with loose blocks present on the face/near the crest of the cut slopes (see photo below) and displaced/fallen rock visible in the ditches.



2.4 SITE DRAINAGE

Regionally, surface water flow is from north to south towards the Saint Lawrence River.

2.5 GEOLOGICAL INFORMATION

The Physiography of Southern Ontario indicates that the site is located within a physiographic region known as the Smiths Falls Limestone Plain. The Surficial Geology Map of Southern Ontario indicates that the Stewart Boulevard bridge structure is located within stone-poor sandy silt to silty sand-textured till on Paleozoic terrain with bedrock drift complex in Paleozoic terrain located to the southwest of the site.



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Previous Investigations / Available Information
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The Paleozoic Geology Map of the Brockville Mallorytown Area indicates that the bedrock at the site is part of the March Formation consisting of interbedded sandstone, dolostone, sandy dolostone, and dolomitic sandstone.

Review of available water well records for wells located in proximity to the bridge site indicates that bedrock was encountered at depths of approximately 0 m to 3 m below ground surface.

3.0 PREVIOUS INVESTIGATIONS / AVAILABLE INFORMATION

No foundation investigation reports were available for this site in the MTO GEOCRE database/library. However, some relevant subsurface information was available on the following drawing:

- 'General Layout - Elizabethtown Township Bridge No. 10A, Elizabethtown Township Underpass Highways 29 & 42, Highway 401', Twp. Drawing No. D-3747-1, prepared by M.M. Dillon & Co. Ltd. Consulting Engineers and dated May 31, 1956.

The drawing includes rock elevation data points at 6 points along the east and west sides of the bridge that range from 335.2 ft to 337.9 ft (~elevations of 102.2 m to 103 m). The drawing indicates that the rock elevation data was collected by D.H.O. (Kingston) in November 1955, and hence would represent the original/pre-construction bedrock surface.

The General Arrangement drawing containing the above noted information is included in Appendix B for reference.

4.0 INVESTIGATION PROCEDURES

4.1 FIELD INVESTIGATION

The current subsurface investigation program consisted of advancing two boreholes, designated as Boreholes SB21-1 and SB21-2, at the site, one on each side of the highway. Borehole SB21-1 was drilled within the grassed area west of the existing south abutment, while Borehole SB21-2 was drilled east of the existing north abutment. The locations of these boreholes are shown on the Borehole Locations and Soil Strata Plan, Drawing No. 1, in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of public utilities.

The boreholes were advanced on May 4th, 2021, using a track-mounted drill rig equipped for soil sampling and rock coring. The boreholes were advanced using continuous hollow-stem augers in the overburden until auger refusal was encountered at depths of approximately 0.9 m and 3.4 m in Boreholes SB21-1 and SB21-2, respectively. Beyond the auger refusal depths, rock coring methods were used to advance the boreholes.

The subsurface stratigraphy encountered in each borehole was recorded in the field by a member of Stantec's geotechnical staff. Standard Penetration Tests (SPTs) were carried out in the overburden and split spoon samples were collected at regular intervals. The bedrock was cored in both boreholes using NQ size equipment. The bedrock



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Investigation Procedures
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cores were placed in core boxes, and the boxes labelled and sealed. All recovered soil samples and bedrock cores were returned to our Ottawa laboratory for detailed classification and testing.

A monitoring well was installed, with a well screen located in the bedrock from 5.7 m to 7.2 m below ground surface, in Borehole SB21-2. The water level was measured in this well on May 7th and May 10th, and the well was subsequently decommissioned. The boreholes were backfilled using bentonite.

4.2 LOCATION AND ELEVATION SURVEY

The borehole locations and respective ground surface elevations for the boreholes were surveyed by Stantec Geomatics division. The borehole survey data is considered accurate to 0.1 m for coordinates and elevations.

Table 4.1 below summarizes the borehole location information with the borehole ground surface elevations, depths and termination elevations.

Table 4.1: Borehole Coordinate and Elevation Information

Borehole	MTM Zone 11 Coordinates		Approximate Ground Surface Elevation (m)	Borehole Depth (m)	Borehole Termination Elevation (m)
	Northing	Easting			
SB21-1	4940226.0	368223.1	104.2	4.6	99.6
SB21-2	4940282.0	368192.3	104.9	7.2	97.8

4.3 Laboratory Testing

All samples were transported to Stantec's Ottawa laboratory where they were visually examined by a geotechnical engineer. The geotechnical laboratory testing program completed on the borehole samples is summarized in Table 4.2.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests
Moisture Content	8
Atterberg Limits	2
Grain Size Distribution (hydrometer)	2
Unconfined Compressive Strength (on bedrock cores)	4
Chemical Analysis	2

The chemical analysis was completed by Paracel Laboratories Ltd. and consisted of testing two samples for pH, soluble sulphate content, chloride content, and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.



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Subsurface Conditions
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5.0 SUBSURFACE CONDITIONS

5.1 FRAMEWORK AND OVERVIEW

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in-situ and laboratory testing are displayed on the Borehole Records included in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix C. The results of geotechnical laboratory testing are presented in Appendix D.

A borehole location plan and stratigraphic section of the soil and bedrock deposits encountered in the boreholes are provided on Drawing No. 1 in Appendix A. The stratigraphic boundaries on the borehole records and the strata plot are inferred from non-continuous sampling and therefore represent transitions between soil types rather than exact boundaries between geological units. The conditions will vary beyond the borehole location.

In general, the subsurface stratigraphy encountered at the borehole locations consisted of a surficial layer of topsoil underlain by approximately 0.3 m of silty clay fill materials in Borehole SB21-1 and by approximately 3.3 m of sandy clayey silt till containing zones of sandy silt till in Borehole SB21-2. The overburden materials were in turn underlain by dolostone to sandy dolostone bedrock at elevations varying from 101.5 m to 103.3 m. Both boreholes were terminated within the bedrock at the depths of 4.6 m and 7.2 m below existing ground surface.

The following sections provide a summary of the subsurface conditions encountered during the investigation.

5.2 OVERBURDEN

5.2.1 Topsoil

A surficial layer of sandy silt topsoil was encountered at ground surface in Boreholes SB21-1 and SB21-2. The thickness of the topsoil varied from approximately 100 mm at Borehole SB21-2 to 600 mm at Borehole SB21-1.

A Standard Penetration Test (SPT) N-value of 4 blows per 0.3 m of penetration was measured within the topsoil in Borehole SB21-2 indicating the topsoil is loose.

Laboratory testing of samples of the topsoil yielded moisture contents of approximately 18% and 27%, expressed as a percentage of the dry weight of the soil.

5.2.2 Fill

Borehole SB21-1 encountered an approximately 0.3 m thick fill layer consisting of silty clay containing trace sand, rootlets, and organic matter below the topsoil.

A SPT N-value of greater than 50 blows per 0.15 m of penetration was measured in the fill. This high penetration N-value is inferred to have been the result of encountering bedrock at the base of the fill. Based on manual examination of the fill, it is considered to have a stiff consistency.



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Laboratory testing of a sample of the fill material yielded a moisture content of approximately 17%.

The fill was approximately 0.3 m thick with the base of the layer encountered at an elevation of approximately 103.3 m.

5.2.3 Clayey Silt to Sandy Silt (Till)

A glacial till deposit comprised of sandy clayey silt containing trace to some gravel, as well as zones of sandy silt till, was encountered underlying topsoil in Borehole SB21-2. Although not visibly confirmed in the borehole, cobbles and boulders are known to be present within the till deposits of Southern Ontario and are expected to be present throughout the till deposits at this site.

SPT N-values varying from 8 to greater than 50 blows per 0.3 m of penetration were measured within the till deposit. Based on the field testing and examination of samples obtained, the cohesive portion of the till deposit is considered to generally have a stiff to hard consistency. The high SPT N-values are inferred to have been influenced by the presence of gravel or other large-sized particles.

Laboratory testing of samples of the till materials yielded moisture contents that ranged from approximately 8% to 14%.

Gradation analyses were carried out on two (2) representative samples of the till deposit. The test results are illustrated on the borehole records in Appendix C and on the gradation curves on Figure No. D1 in Appendix D.

Atterberg Limits tests were carried out on portions of the samples referenced above. The tests yielded Liquid Limits of 25% and 15%, Plastic Limits of 16% and 12%, and corresponding Plasticity Indices of 9% and 3%. The results of the tests are illustrated on the borehole records in Appendix C and on Figure No. D2 in Appendix D.

Based on the gradation and Atterberg Limit test results, the USCS group symbols for the samples of the glacial till tested vary from ML (sandy silt till) to CL (sandy clayey silt till).

5.3 BEDROCK

Slightly weathered to fresh, dolostone to sandy dolostone bedrock was encountered beneath the overburden in both boreholes. The presence of bedrock was confirmed by coring. The depths to the top of bedrock are summarized in Table 5.1 below.

Table 5.1: Bedrock Surface Depth/Elevation

Borehole	Depth (m)	Elevation (m)
SB21-1	0.9	103.3
SB21-2	3.4	101.5

Table 5.2 provides a summary of the rock core data. Photographs of the rock cores from each of the boreholes are included in Appendix C.



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Table 5.2: Summary of Bedrock Coring Operations

Borehole No.	Run No.	Rock Description	Depth below ground (m)	Geodetic Elevation (m)	Total Core Recovery, TCR (%)	Solid Core Recovery, SCR (%)	Rock Quality Designation, RQD (%)	Weathering Degree (W1=Fresh, W2=Slightly Weathered)	Fracture Index (fractures per m)
SB21-1	3	Slightly weathered to fresh, tan to dark grey Dolostone to Sandy Dolostone	0.9-1.5	103.3-102.7	100	100	92	W2	5
	4		1.5-3.0	102.7-101.2	98	96	50	W2	9
	5		3.0-4.6	101.2-99.6	99	98	68	W2/W1	8
SB21-2	6	Slightly weathered to fresh, tan to dark grey, Dolostone to Sandy Dolostone	3.4-4.7	101.5-100.2	100	100	77	W2	5
	7		4.7-6.2	100.2-98.7	97	93	54	W1	13
	8		6.2-7.2	98.7-97.8	97	97	67	W1	9

Based on the range of RQD values, the bedrock can be classified as being of fair to excellent in quality.

Four (4) rock cores samples were selected for testing to determine their Unconfined Compressive Strength (UCS). The results of these tests are summarized in Table 5.3 below.

Table 5.3: Results of Unconfined Compressive Strength (UCS) on Rock Core Samples

Borehole No.	Run No.	Sample Depth (m below ground)	Sample Elevation (m)	Unconfined Compressive Strength (UCS) (MPa)
SB21-1	3	1.0	103.2	235.2
	5	4.0	100.2	134.7
SB21-2	6	4.1	100.8	89.9
	8	6.6	98.3	126.0

The results of the UCS tests carried out on the rock cores ranged from 89.9 MPa to 235.2 MPa, indicating that the dolostone bedrock can be classified as strong (R4) to very strong (R5).

5.4 GROUNDWATER CONDITIONS

The water level in the monitoring well installed within the bedrock at Borehole SB21-2 was measured to be at a depth of approximately 5.7 m (corresponding to an elevation of about 99.2 m) on both May 7th and May 10th, 2021.

Groundwater levels at the site will be subject to fluctuations due to seasonal changes, snowmelt, and precipitation events. The water levels should be expected to be higher during the spring season and during and following periods of heavy precipitation or snow melt.



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Miscellaneous
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5.5 CHEMICAL ANALYSIS

Chemical analyses related to parameters associated with the potential for corrosion or sulphate attack (i.e., pH, resistivity, and chloride and sulphate content) were carried out by Paracel Laboratories Inc. on two representative soil samples. The analysis results are provided in Appendix D and are summarized in Table 5.4.

Table 5.4: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Resistivity (Ohm-m)	Chloride (µg/g)	Sulphate (µg/g)
SB21-2	SS3	1.5-2.1	7.58	80.0	13	6
SB21-2	SS5	3.0-3.4	7.89	102.0	11	10

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Karl Thom under the direction of Kevin Nelson, P.Eng.

The utility locates for the boreholes were arranged by Stantec personnel.

The drilling equipment was supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge, Quebec. Traffic control service was provided by Beacon Lite of Ottawa, Ontario.

The location and elevation survey of the boreholes was completed by Stantec's Geomatics division.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory. The chemical testing for pH, soluble sulphate and chloride contents, and soil resistivity was carried out by Paracel Laboratories Ltd. of Ottawa.

This report was prepared by Zach Popper, P.Eng. and reviewed by Kevin Nelson, P.Eng., and Raymond Haché, M.Sc., P.Eng., Designated Principal MTO Foundation Contact.



**PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS
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Closure
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7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted,

STANTEC CONSULTING LTD.

Zach Popper, P.Eng.
Geotechnical Engineer



Kevin Nelson, P.Eng.
Principal, Senior Geotechnical Engineer



Raymond Haché, M.Sc., P. Eng.
MTO Designated Principal Foundation Contact



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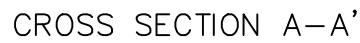
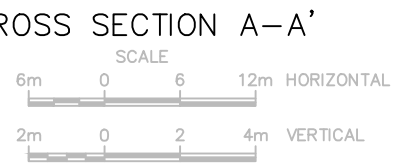
**PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS
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APPENDIX A

A.1 DRAWING NO. 1 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOT





SHEET
—



No	ELEV	MTM ZONE 9 COORDINATES	
		NORTH	EAST
SB21-1	104.2	4 940 226.0	368 223.1
SB21-2	104.9	4 940 282.0	368 192.3

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

GEOCRES No 31B-107

HWY No 401		DIST	
SUBM'D KN	CHECKED	DATE 2023-02-15	SITE 16-121
DRAWN GBB	CHECKED	APPROVED RH	DWG 1

**PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS
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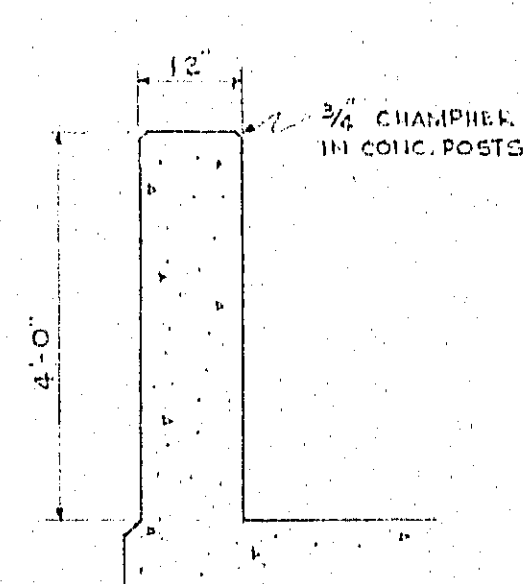
February 2023

APPENDIX B

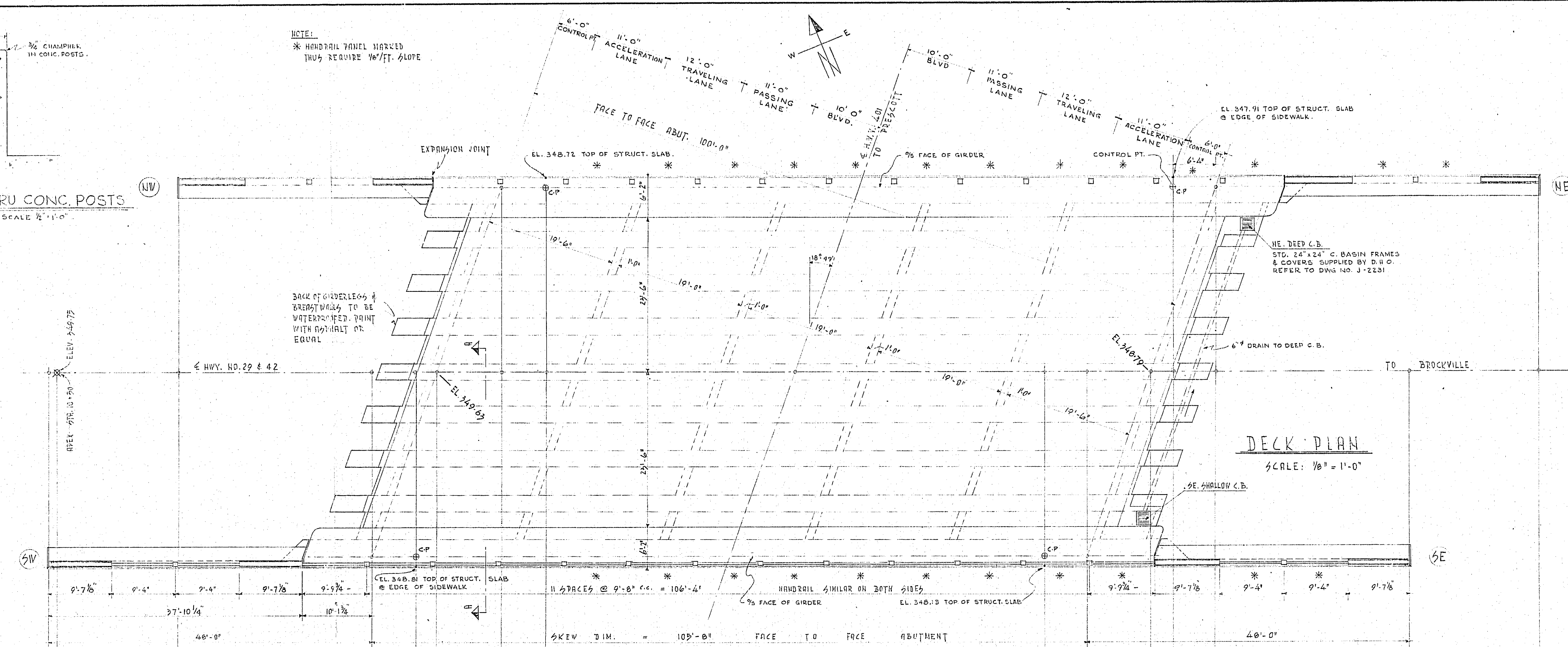
B.1 AVAILABLE SUBSURFACE INFORMATION



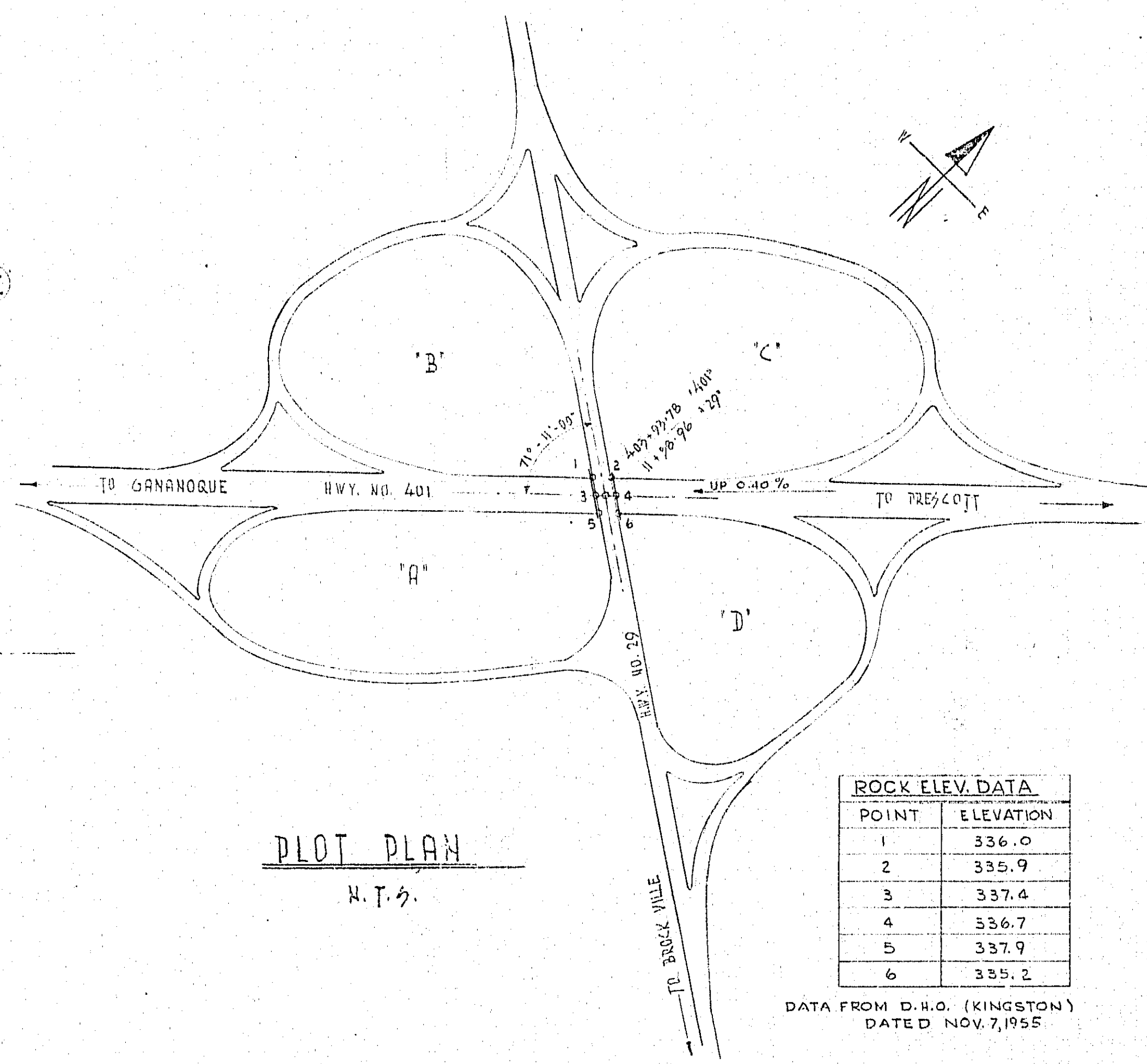
SECT THRU CONC. POSTS
SCALE 1/2" = 1'-0"



NOTE:
* HANDRAIL PANEL MARKED
THUS REQUIRE 1/8" SLOPE



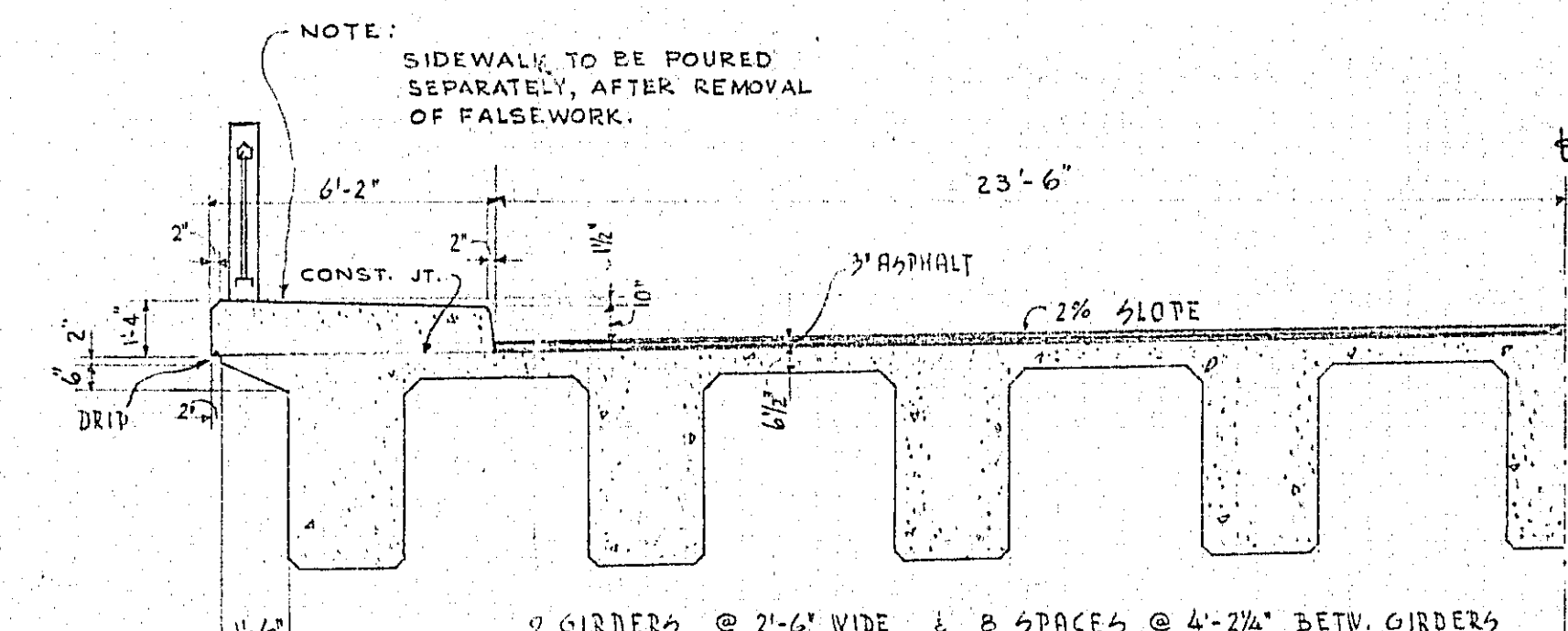
DECK PLAN
SCALE: 1/8" = 1'-0"



PLOT PLAN
N.T.S.

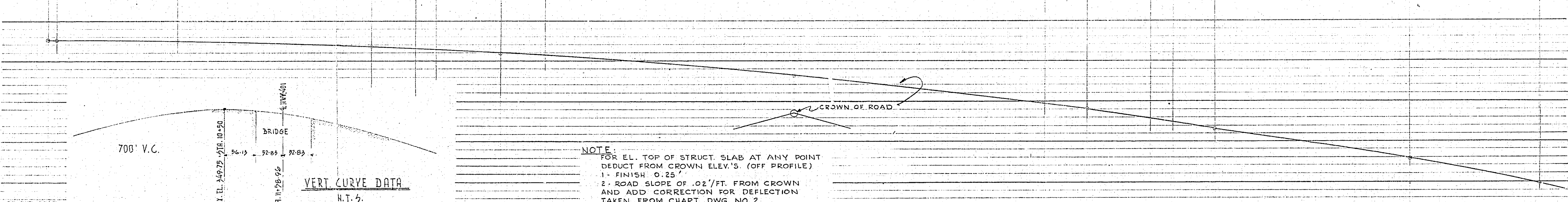
POINT	ELEVATION
1	336.0
2	335.9
3	337.4
4	336.7
5	337.9
6	335.2

DATA FROM D.H.O. (KINGSTON)
DATED NOV. 7, 1955



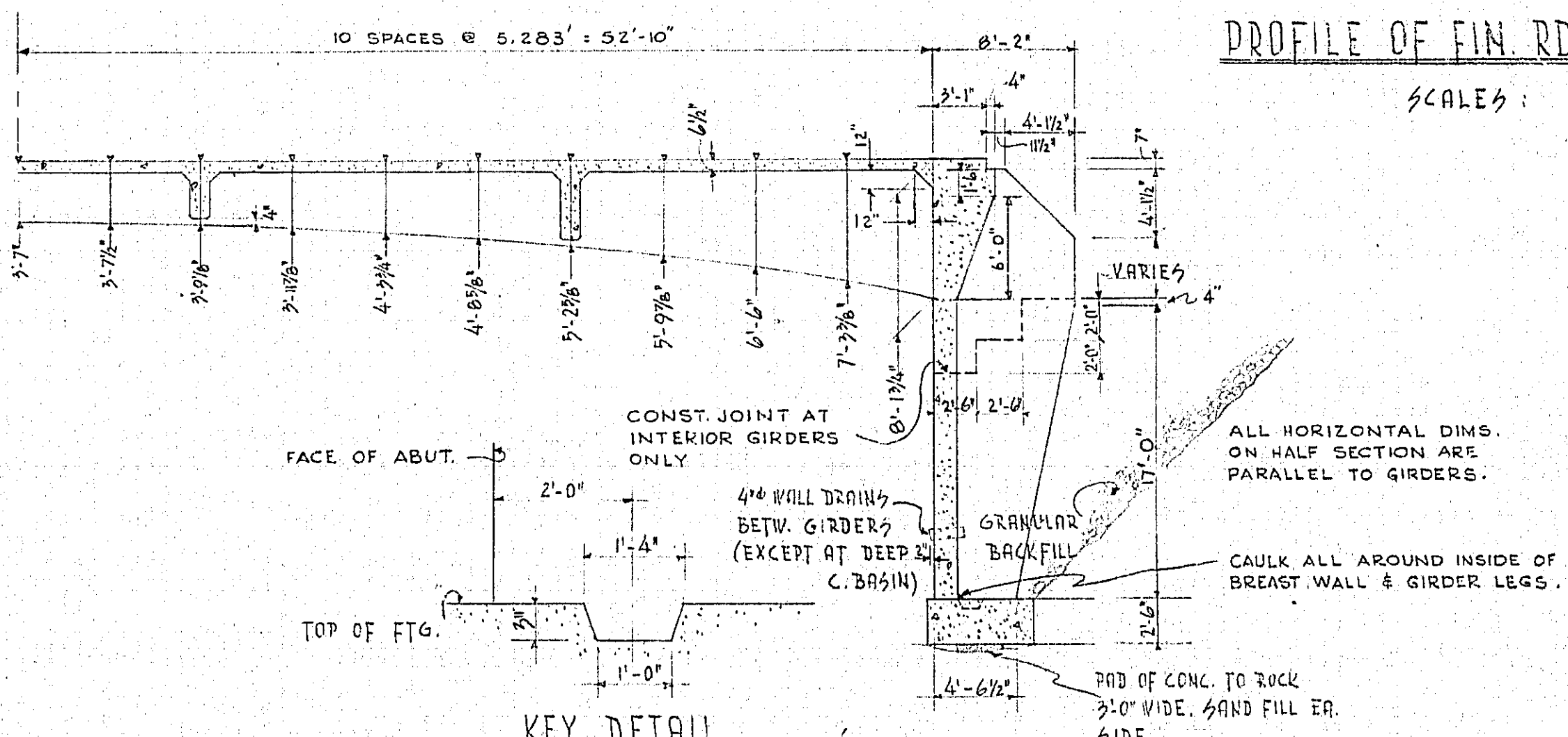
SECTION 'A-A'
SCALE: 1/4" = 1'-0"

VERT. CURVE DATA
N.T.S.

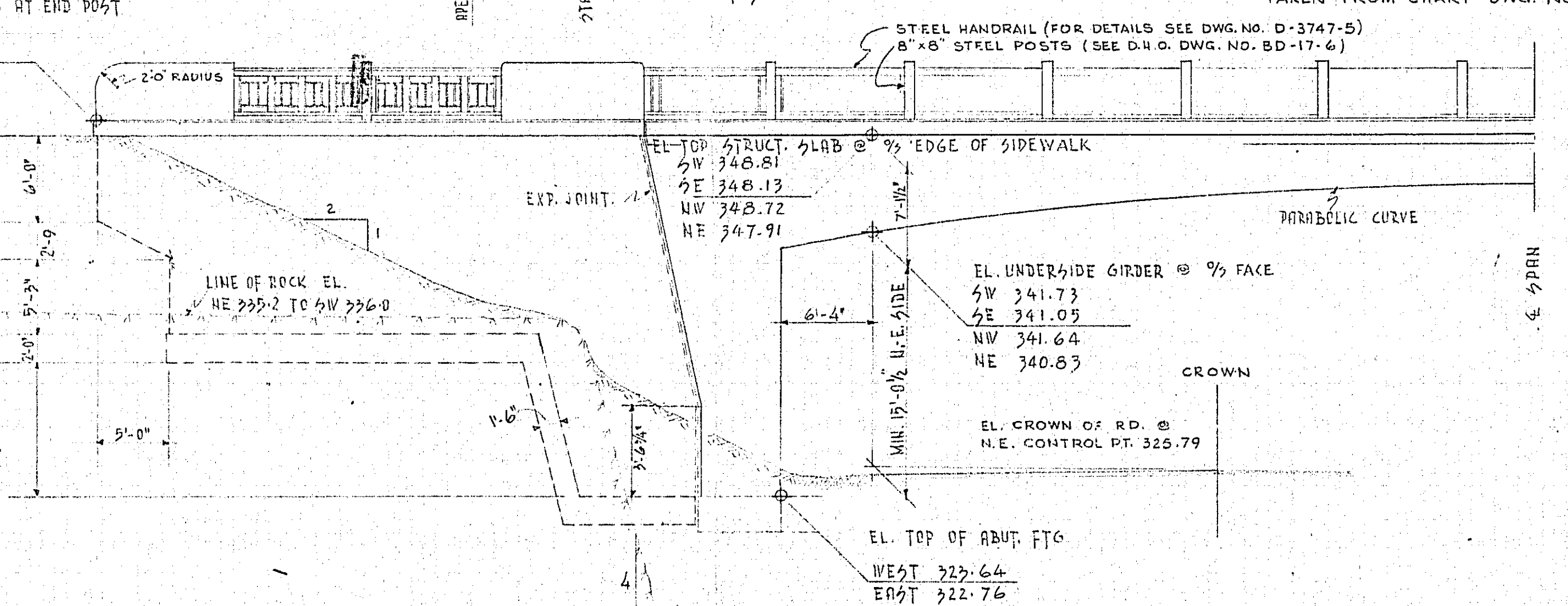


PROFILE OF FIN. RD. EL. ALONG 4 OF HWY NO. 29 & 42
SCALE: HORIZ. 1/8" = 1'-0"
VERT. 1/2" = 1'-0"

NOTE:
FOR EL. TOP OF STRUCT. SLAB AT ANY POINT
DEDUCT FROM CROWN ELEV. (OFF PROFILE)
1. FINISH D. 2.5"
2. ROAD SLOPE OF .02'/FT. FROM CROWN
AND ADD CORRECTION FOR DEFLECTION
TAKEN FROM CHART DWG. NO. 2

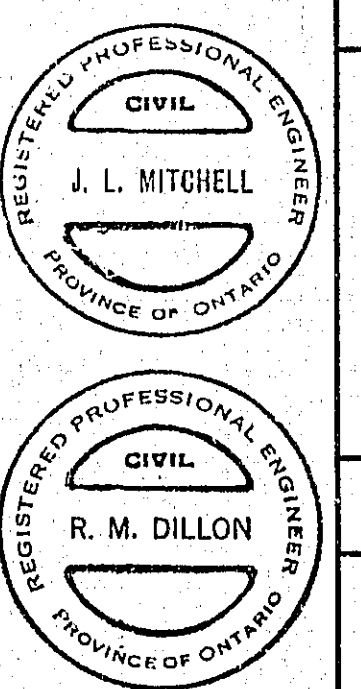


KEY DETAIL
SCALE: 1/8" = 1'-0"



HALF ELEVATION
SCALE: 1/8" = 1'-0"

NO.	FOR	DATE
1	DESIGN	11-27-55
2	REVISION	11-27-55
3	REVISION	11-27-55
4	REVISION	11-27-55
5	REVISION	11-27-55
6	REVISION	11-27-55
7	REVISION	11-27-55
8	REVISION	11-27-55
9	REVISION	11-27-55
10	REVISION	11-27-55



ELIZABETHTOWN TWP BRIDGE # 10A	
M. M. DILLON & CO. LTD. 1188 NO. 1000 CONSULTING ENGINEERS TORONTO	
DEPARTMENT OF HIGHWAYS-ONTARIO BRIDGE OFFICE-TORONTO	
ELIZABETHTOWN TWP UNDERPASS HIGHWAYS 29 & 42	
THE KING'S HIGHWAY No. 401	DIV. No. 8
CO. LEEDS	
TWP. ELIZABETHTOWN	LOT 13 CON. I
GENERAL LAYOUT	
APPROVED:	
BRIDGE ENGINEER	CHIEF ENGINEER
DESIGN J.L.M. CHECK B.T.L. CONTRACT NO. 57-53	
DRAWING A.W. CHECK W.C.O. LOADING	
TRACING A.W. CHECK W.C.O. LOADING	
DATE MAY 31, 1956	DRAWING NUMBER D-3747-1

TWP# 25-12-1-10
1 to 9

**PRELIMINARY FOUNDATION INVESTIGATION REPORT - STEWART BOULEVARD UNDERPASS
REPLACEMENT - SITE NO. 16X-0121/B0**

February 2023

APPENDIX C

C.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS

C.2 BOREHOLE RECORDS (CURRENT INVESTIGATION)

C.3 BEDROCK CORE PHOTOGRAPHS



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Rootmat</i>	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	Very Poor Quality
25-50	Poor Quality
50-75	Fair Quality
75-90	Good Quality
90-100	Excellent Quality

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	Crushed
Severely Fractured	Shattered or Very Blocky
Fractured	Blocky
Moderately Jointed	Sound
Intact	Very Sound

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	Extremely Wide	-
2000-6000	Very Wide	Very Thick
600-2000	Wide	Thick
200-600	Moderate	Medium
60-200	Close	Thin
20-60	Very Close	Very Thin
<20	Extremely Close	Laminated
<6	-	Thinly Laminated

Terminology describing rock strength:

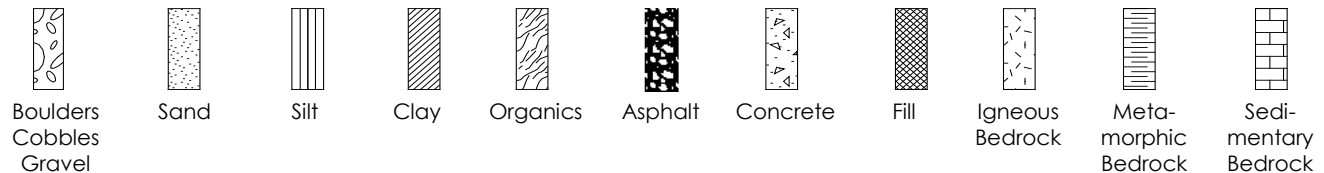
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

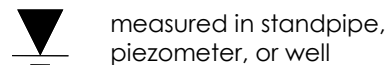
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No SB21-2

1 OF 1

METRIC

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N:4940282.0 E:368192.3 ORIGINATED BY KT
 DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger + NQ Rock Coring COMPILED BY KL
 DATUM Geodetic DATE 2021.05.04 - 2021.05.04 LATITUDE 44.599754 LONGITUDE -75.701467 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
104.9 0.1	SANDY SILT (TOPSOIL) Dark brown Moist Sandy CLAYEY SILT (CL), trace to some gravel (TILL). Contains zones of SANDY SILT (ML), trace gravel (TILL). Stiff to hard Brown Moist																

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



Project No.: 165001160

Project Name: Hwy 401-Stewart Blvd. Underpass

Rock Core
Photographs



Rock Core Photo No.: 1

Borehole: SB21-1

Depth: 0.9 m to 4.6 m



Rock Core Photo No.: 2

Borehole: SB21-2

Depth: 3.4 m to 7.2 m

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REPLACEMENT - SITE NO. 16X-0121/B0**

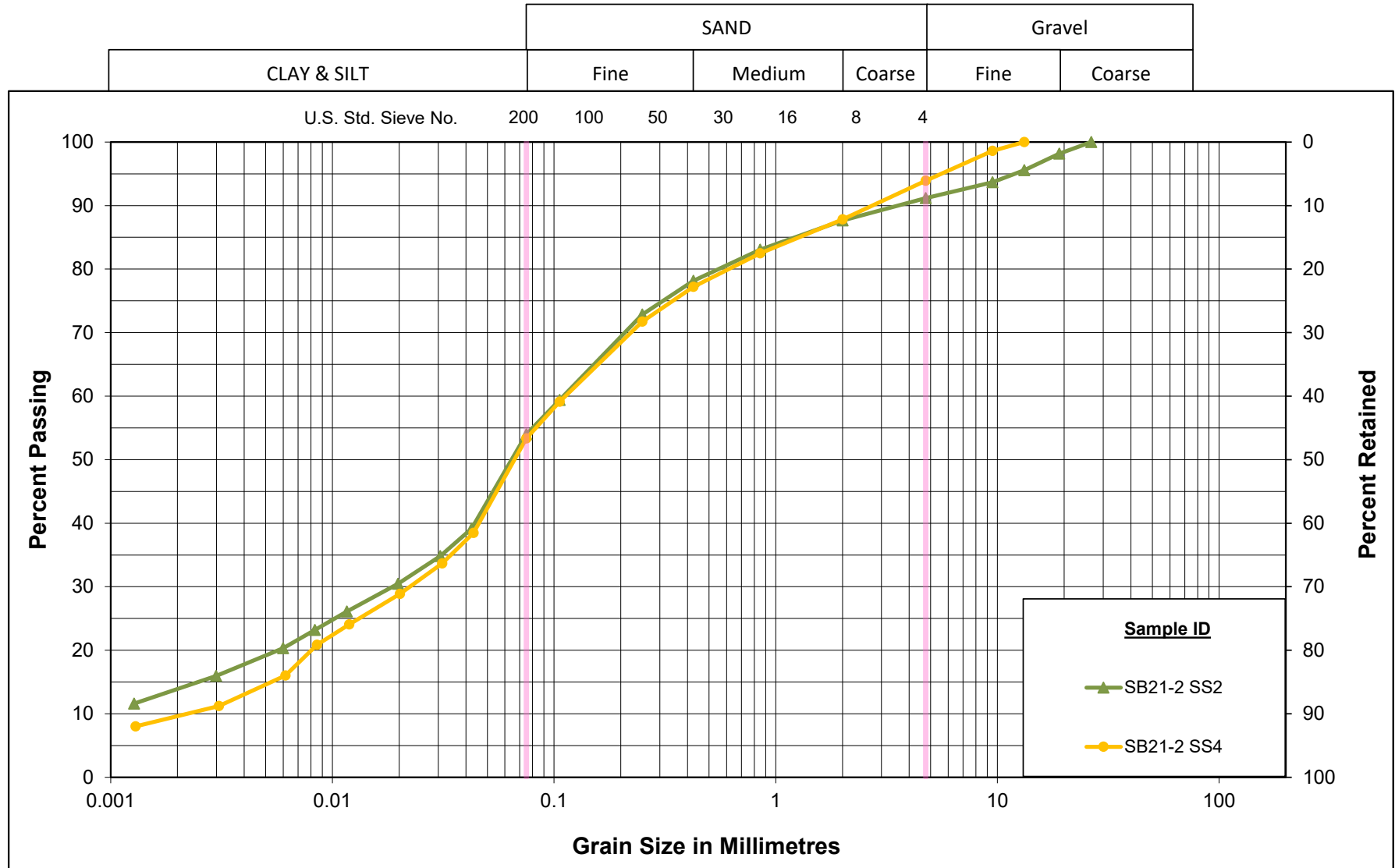
February 2023

APPENDIX D

D.1 LABORATORY TEST RESULTS



Unified Soil Classification System



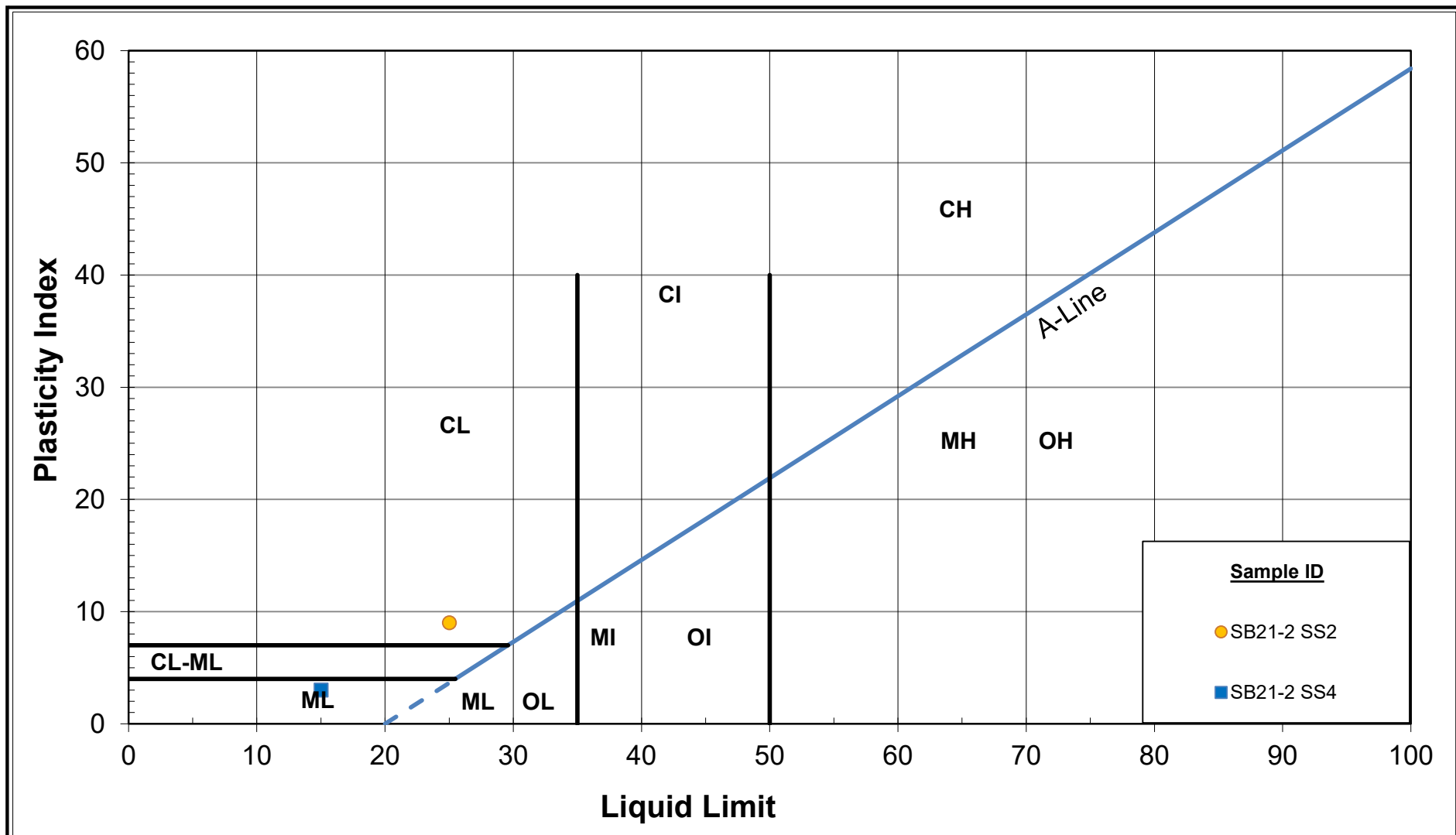
GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT (CL) to SANDY SILT (ML) (TILL)

Highway 401 Brockville - Stewart Boulevard Underpass

Figure No. D1

Project No. 165001160



Stantec

Sandy CLAYEY SILT (CL) to SANDY SILT (ML) (TILL)
Highway 401 Brockville - Stewart Boulevard Underpass

PLASTICITY CHART

Figure No. D2

Project No. 165001160.309

Certificate of Analysis

Report Date: 16-Jun-2021

Client: Stantec Consulting Ltd. (Ottawa)

Order Date: 11-Jun-2021

Client PO: Hwy 401 Brockville EA

Project Description: 165001160.309

Client ID:	CP21-1, SS14.10.668-11.278m	BC21-1,SS3.1.524-2 .134m	BC21-2,SS3.1.524-2. 134m	NA21-1,SS3.1.524- 2.134m
Sample Date:	10-May-21 09:00	05-May-21 09:00	05-May-21 09:00	03-May-21 09:00
Sample ID:	2124634-01	2124634-02	2124634-03	2124634-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	90.5	78.7	77.4	82.1
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General Inorganics

pH	0.05 pH Units	7.90 [1]	7.48 [1]	7.81 [1]	7.45 [1]
Resistivity	0.10 Ohm.m	32.8	16.3	15.1	39.8

Anions

Chloride	5 ug/g dry	36 [1]	244 [1]	264 [1]	27 [1]
Sulphate	5 ug/g dry	177 [1]	72 [1]	49 [1]	26 [1]

Client ID:	NA21-2,SS15.12.192- 12.802m	OS21-1,SS2.0.254- 0.609m	OS21-2, SS3B.1.829-2.134m	SB21-2,SS3.1.524- 2.134m
Sample Date:	06-May-21 09:00	07-May-21 09:00	11-May-21 09:00	04-May-21 09:00
Sample ID:	2124634-05	2124634-06	2124634-07	2124634-08
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	87.0	80.0	99.5	99.5
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General Inorganics

pH	0.05 pH Units	7.94 [1]	7.62 [1]	7.91 [1]	7.58 [1]
Resistivity	0.10 Ohm.m	12.6	44.3	30.2	80.0

Anions

Chloride	5 ug/g dry	388 [1]	22 [1]	118 [1]	13 [1]
Sulphate	5 ug/g dry	86 [1]	8 [1]	16 [1]	6 [1]

Client ID:	SB21-2,SS5.3.048-3.3 53m	CP21-2,SS5.3.048- 3.658m	-	-
Sample Date:	04-May-21 09:00	12-May-21 09:00	-	-
Sample ID:	2124634-09	2124634-10	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	100	99.2	-	-
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General Inorganics

pH	0.05 pH Units	7.89 [1]	7.81 [1]	-	-
Resistivity	0.10 Ohm.m	102	16.2	-	-

Anions

Chloride	5 ug/g dry	11 [1]	212 [1]	-	-
Sulphate	5 ug/g dry	10 [1]	51 [1]	-	-